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CHARACTERISTICS OF METABOLISM DURING
LONG WATER IMMERSION

by

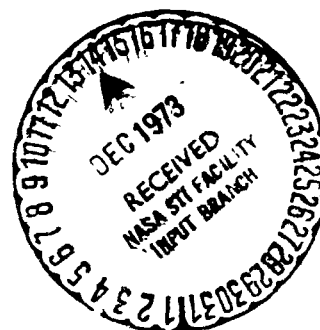
R. A. Tigranyan

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CHARACTERISTICS OF METABOLISM DURING
LONG WATER IMMERSION

R. A. Tigranyan

Abstract: The effect on the organism of a 12-day stay in a water immersion medium (head on the water surface) was studied on 10 subjects.

The condition of the metabolic processes in the subjects was judged from the investigation of the parameters of protein and carbohydrate metabolism, acid-base equilibrium, the activity of a number of enzymes and steroid hormones. The venous blood and diurnal urine served as the material for conducting the corresponding biochemical determinations.

The stay in an immersion medium is accompanied by a significant reduction in the content of residual nitrogen in the blood, by a reduction of the creatinine content in the blood and by an increase of the creatine content of the blood with the simultaneous increase of the excretion of creatinine and creatine with the urine, by a significant increase of the glucose and lactate content in the blood, by the development of acidosis of a respiratory and metabolic character, as well as by a significant increase of the activity of creatine phosphokinase and the isoenzyme fraction of lactate dehydrogenase₃. In all the subjects, an expressed intensification of the glucocorticoid and androgenic functions of the adrenal cortex is noted during the experimental period,

which attests to the presence of stress.

The single direction of the changes noted after space flights and simulated experiments conducted under earth gravity conditions offer the basis to presuppose that certain effects of weightlessness can be simulated under terrestrial conditions.

Weightlessness in turn affects hemodynamics since the orthostatic gradient of blood pressure disappears, and this serves as the starting mechanism for a number of other processes including changes in metabolism.

The stay of men in a horizontal position in water (water immersion) is a most adequate model of the redistribution of the blood analogous to that expected under conditions of weightlessness. During the stay of a person in water, the weight of the blood becomes equal to the weight of the displaced fluid, therefore, the blood does not accumulate in the lower parts of the body due to the force of gravity.

It should be noted that water immersion is considered a stricter model of weightlessness in comparison with hypokinesia for the reason that in a horizontal position in a bed, even though the orthostatic gradient is eliminated and the blood does not accumulate in the lower extremities, some quantity of blood can be deposited in the lower soft tissues.

The study of certain aspects of metabolism during the stay of a person in a water immersion medium has been conducted by a number of authors (1-5), however the length of the stay in the immersion medium did not exceed six days.

We conducted a study of the characteristics of metabolism during a long (12 days) stay in an immersion medium.

Study of the effect of a 12-day stay in a water immersion medium (head on the water surface) on the organism was conducted on 10 subjects. All the subjects were subjected to acceleration in the "head - pelvic" direction with a 3 g value for 5 minutes immediately before and after the stay in the water immersion; five subjects were subjected to accelerations of 0.75 - 1.5 g for 1 - 1.5 hours daily during the last six days of immersion.

The condition of the metabolic processes in the subjects was judged from the investigation of a number of parameters of protein metabolism (total protein, albumin, globulins, A/G coefficient, residual nitrogen, urea, uric acid, creatine, creatinine, thymol test), carbohydrate metabolism (glucose, lactic acid, pyruvic acid), acid-base equilibrium (pH, pO₂, pCO₂, BE, SB, AB, total CO₂), activity of a number of enzymes (aldolase, basic phosphatase, creatine phosphokinase, glutamate-oxalate-transaminase, glutamate pyruvate-transaminase, lactate dehydrogenase and its isoenzymes) and the activity of the steroid hormones (11-hydroxycortico-steroids, 17-hydroxycorticosteroids, 17-ketosteroids, dehydroepiandrosterone).

The investigations were conducted before, during and after the period of water immersion according the following scheme: background examination, examination before and after accelerations immediately before placement in the immersion medium, later on the 4th, 6th, 10th and 12th day of

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the stay in the immersion medium, before and after accelerations at once after coming out of immersion and on the 2-3rd, 7-8th and 11-12th days of the post-experimental period.

Venous blood and diurnal urine served as the material for conducting the corresponding biochemical determinations; the parameters of the acid-base equilibrium were determined from blood taken from a finger.

The experiments conducted yielded the following results:

Protein Metabolism. We were not able to observe substantial changes in the content of the total protein of the blood in all the subjects both in the course of the stay in the immersion medium as well as in the period of the after-effects; the variations noted were multidirectional, insignificantly expressed and did not exceed the limits of the physiological norm. As far as the albumin and globulins content as well as the A/G coefficient value are concerned, in 8 subjects there were not observed substantial changes in the value of the indicated indices either in the experiment itself or in the post-experimental period, while in 2 subjects on the 10th and 12th day of the stay in the immersion medium there was noted a sharp reduction of the albumin content and an increase in the globulins contents as well as a significant reduction of the A/G coefficient value, while the indicated changes exceeded the limits of the generally accepted norm; it is interesting to note that both subjects were found in the group which was subjected to daily accelerations in the last 6 days of immersion.

The stay in the water immersion medium is accompanied by a significant increase in the content of residual nitrogen in the blood up to a level exceeding the upper boundary of the norm, and this increase is maintained even in the after-effects period (Figure 1); the observed changes were noted in 8 subjects.

Both in experiment itself and in the after-effects period, in all subjects, there were not observed substantial changes in the urea content of the blood; the variations noted were insignificant and multi-directional. At the same time, in 5 subjects a considerable increase of the urea excretion with urine was noted, up to a value exceeding the limits of the generally accepted norm, both in the stay in the immersion medium as well as in the post-experimental period.

The long water immersion leads to an increase exceeding the normal values of the uric acid content in the blood in 5 subjects; the noted increase is maintained even in the post-experimental period. As far as the uric acid excretion with urine is concerned, its values in all subjects both in the experiment itself as well as in the post-effects period undergo insignificant changes, varying within the limits of the norm.

The stay of the subjects in the immersion medium is accompanied by a certain reduction in the creatinine content of the blood, not exceeding, however, the norm limits, in all subjects; in the post-effects period the creatinine content of the blood returned to the initial level. At the same time, water immersion is accompanied by an

increase in the creatinine excretion with the urine exceeding the limits of normal variations, in all subjects, although a normalization of creatinine removal in the urine is noted in the post-experimental period (Figure 2).

As far as the creatine content in the blood and its excretion with urine are concerned, in 8 subjects, the stay in the immersion medium is accompanied by an increase in the indicated indices up to a level exceeding the upper boundaries of the physiological norm and by a return to the initial level in the post-effects period (Figure 2).

In the all the subjects both in the stay in immersion as well as in the post-experimental period, there were not observed substantial changes in the value of the thymol test; the available variations were insignificant and multidirectional.

Carbohydrate Metabolism. The stay in the immersion medium is accompanied by a significant increase in the glucose content of the blood (exceeding the limits of normal values) at the 10th and 12th days of the immersion of 5 subjects; in the remaining periods of the experiment as well as in the other subjects in the course of the entire experimental period as well in all subjects in the post-experimental period, multi-directional variation in the glucose content of the blood, not exceeding, however, the limits of normal values are observed (Figure 3).

Immersion is accompanied by a significant increase in the lactic acid content of the blood up to a level exceeding the upper boundary of the

norm, in 5 subjects; in the post-effects period the lactic acid content of the blood in these subjects returned to the initial level (Figure 3).

As far as the pyruvic acid content of the blood is concerned, in all the subjects both during the water immersion period as well as in post-experimental period, multidirectional variations within the limits of the generally accepted norm are noted.

Acid-Base Equilibrium. The stay in the immersion medium is accompanied by the development of acidosis of a respiratory and metabolic character in all subjects. In the posteffects period, all the subjects maintained respiratory acidosis; a return to the norm of the indices of the acid-base equilibrium of the blood is noted only on the 11-12th day of the post-experimental period.

Enzymes. The indicators of the activity of aldolase and basic phosphotase varied multidirectionally in all subjects during the experimental and post-experimental periods; the variations noted thusly were insignificant and were found in the limits of the norm.

The stay in the immersion medium was accompanied by an increase of the activity of the glutamate pyruvate-transaminase and by a decrease of the activity of glutamate oxalate-transaminase; the indicated changes were insignificant, not exceeding the limits of the generally accepted norm and returned to the initial level in the post-experimental period.

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As far as the activity of creatine phosphokinase is concerned, there were no substantial changes in the activity of the enzyme both in the experiment and in the aftereffects period in 6 subjects; at the same time, a significant increase of activity of creatine phosphokinase is noted in 4 subjects in the experimental period, which became sharply expressed on the 10th and 12th days of immersion, reaching a level of the upper boundaries of the norm which, in our opinion, can attest to the presence of possible atrophic changes in the skeletal musculature (Figure 4).

Insignificant variations of the total activity of lactate dehydrogenase (LDH), not exceeding the limits of the generally accepted norm, were noted in all subjects both in the experiment and in the post-experimental period. The investigation of the activity of the LDH isoenzymes did not reveal substantial changes in all periods of the investigations with the exception of the presence of an increase (exceeding normal limits) of LDH₃ activity in 6 subjects both during the immersion stay and in posteffects period (Figure 4); these changes attest to the presence of a possible reaction from the direction of the endocrine system.

Hormones. The investigation of the excretion of total 17-ketosteroids (17-KS) and dehydroepiandrosterone (DHA) indicated that the stay in the immersion medium is accompanied by multidirectional variations of 17-KS excretion, not exceeding, however, the limits of the generally accepted norm and by a significant increase in the level of DHA excretion

(2-3 times exceeding the upper boundary of the norm) in all subjects, which evidently is a response to stress; in the post-experimental period, a tendency to a normalization of the DHA excretion level and the return to initial values on the 11-12th day of the posteffects are noted (Figure 5).

Study of the secretion of 11-hydroxycorticosteroids (11-HCS) did not reveal substantial changes in all subjects either in the experimental process or in the post-experimental period; the existing variations were insignificant and did not exceed normal limits. As far as the excretion of 11-HCS is concerned, its increase in all subjects up to the level of the upper boundaries of the norm or even somewhat higher was noted in the experimental period; a tendency to normalization is clearly observed in the post-effects period.

The stay in the immersion medium is accompanied by a significant increase in the level of excretion of 17-hydroxycorticosteroids (17-HCS) in all subjects; the significant increase (beyond normal limits) of the total 17-HCS fractions as well as those bound with beta-glucuronic acid with the simultaneous decrease of the free form of 17-HCS attest to this; the indicated changes do not reach the level of normal values even at the end of the post-experimental period (Figure 6).

The obtained data attest that in all subjects in the course of the stay in the immersion medium an expressed intensification of the glucocorticoid and androgenic functions of the adrenal cortex is noted, which attests to the presence of stress.

Legends for the Figures

- Figure 1. Content of the residual nitrogen in the blood (mg%).
- Figure 2. Content of creatinine and creatine in the blood (mg% and in the urine (mg/24).
- Figure 3. Content of glucose and lactate in the blood (mg%).
- Figure 4. Activity of creatine phosphokinase (in units) and LDH₃ (in %) in the blood.
- Figure 5. Excretion of dehydroepiandrosterone with the urine (DHA in mg/24).
- Figure 6. Excretion of 17-hydroxycorticosteroids with the urine (total - in mg/24, free and bound with beta-glucuronic acid, in %).

Note. The designations on the figures:

- 1 - background
- 2 - immersion
- 3 - post-experimental period.

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1. GOODAL, Mc.C.
CALLY, Mc.M.,
GRAVELINO, D.E.
Urinary adrenoline and noradrenoline response to simulated weightless state.
Am.J.Physiol., 206, 2, 431-436, (1964).
2. TORPHY, D.E.
Effects of short-term bed rest and water immersion on plasma volume and catecholamine response to titling.
Aerosp.Med., 37, 4, 383-385, (1966).
3. EPSTEIN, M.,
FISHERMAN, L.M.,
HALE, H.B.
Dissociation of aldosterone and 17-hydrocorticosteroid (17-OHCS) release during water immersion in normal man.
Proc.Soc.Exptl.Biol.and Med. 138,
3, 939-942, (1971).
4. GAUER, O.H.
Selected features of reflex blood volume control and their possible bearing on physiological changes in the weightless condition.
IX International Man-in-Space Symposium. Abstracts. Jerevan, USSR, 71-73, (1971).
5. SAIKI, H.,
NAKAYA, M.,
MIZUNUMA, H.
Metabolic and Hormonal Effects of Prolonged Hypodynamics.
Space Medicine Laboratory, Tokyo,
Jikeikai University School of Medicine, Tokyo, Japan, (1972).